SASKATCHEWAN SOIL SALINITY PROGRAM PROGRESS REPORT [1.]

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Significant progress was made during the 1976 season in consolidating seven of the eight salinity research-demonstration sites which were established in 1975. The site near Borden proved to be unsatisfactory and was dropped from the list. Two new sites were selected in 1976, one at Birsay and one at Glenside (Refer Fig. 1).

On the seven continuing sites definite rotation plans were instituted comparing continuous grain cropping and a continuous grain cropping-sweet clover combination with a two year summerfallow-grain rotation. At four sites an alfalfa-grass rotation was also included.

The stubble cropped fields in 1976 were fertilized with 23-23-0 at 88 to 143 kilograms per hectare. Unfertilized check strips were left for comparison purposes. Spring and fall soil samples were taken and crop samples were harvested at maturity. In October observation wells were drilled in three nests at two depths, approximately 6 feet and 10 feet, on Forman site, Moose Jaw; Alexander site, Landis; and Siemens site, Rosthern.

Yield data and soil test results for 1976 field strip experiments on research-demonstration sites have not yet been completely analyzed. An example of the information being gathered, however, is shown in Table 1 for Siemens site, Rosthern.

One interesting aspect from these unworked data is the noticeable increase in NO_3-N as the salinity level increases. The average EC increases steadily from 0.53 mmhos per cm at sample location SS4 to 12.79 mmhos per cm at sample location SS1. NO_3-N levels measure 73.7 kg/ha at low salinity, double to approximately 140 kg/ha at medium salinity, stay at this level as salinity readings increase to a high 8.95 mmhos/cm, then double again to 275 kg/ha as salinity jumps to a very high 12.79 mmhos reading.

Barley grain yields on Siemens plots remain fairly steady at around 2800 kg/ha and yield responses to fertilizer range quite consistently at roughly 140% increase through salinity readings 0.53 to 6.61 mmhos/cm conductivity. As salinity levels increase beyond 6.61 mmhos yields drop off sharply at the highest salinity readings and response to fertilizer is not as great. It will be noted that the unusually low yield and high response for sample location SN4 could have been due to flooding damage.

Yield data and soil test results from Siemens and from the other salinity research demonstration sites will be key punched and analyzed by computer. This will provide a series of correlations and linear regressions on a variety of parameters including salinity levels at various depths, nitrate levels at various depths, phosphate levels at the surface, fertilized and unfertilized yields and yield change. Multiple regression between salinity, nitrogen and phosphorus levels will also be run. This information will be presented at a future workshop.

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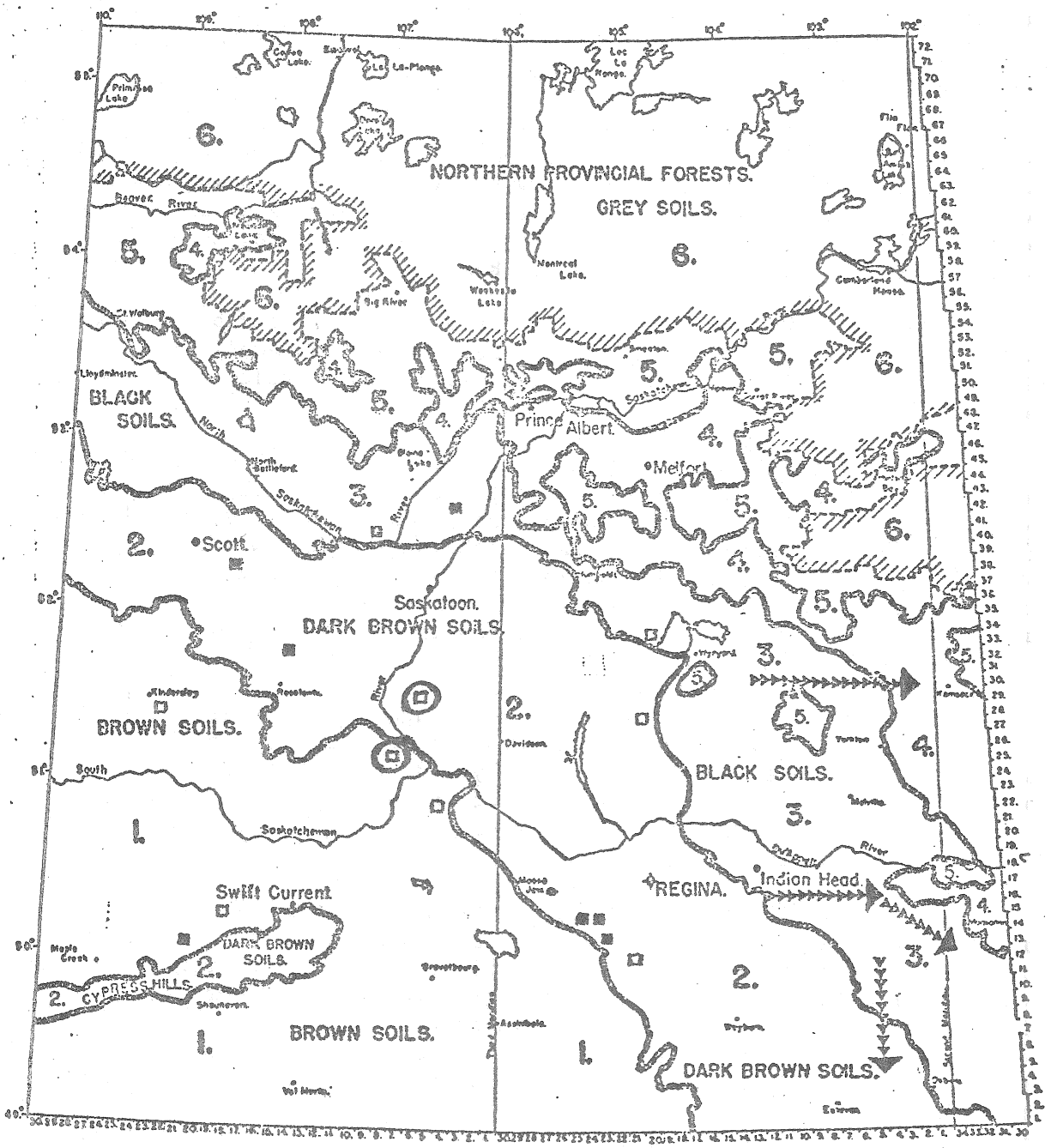
1. Research and technical input to the salinity program by Archie Ballantyne, John Peters and others from the Saskatchewan Institute of Pedology and Frank Warder, Wally Nicholaichuk and others from Swift Current Research Station is herein acknowledged.

FIG. 1. SASKATCHEWAN SALINITY PROGRAM RESEARCH-DEMONSTRATION SITES

■-1975 site locations

□-1976 proposed site locations ⊡-developed in 1976

➤➤-areas for future site locations



—LEGEND—

1. Brown Soils of the open prairie, the most arid section of the province. Wide variations in crop yields and frequent severe droughts.
2. Dark Brown Soils of the prairie, less arid than the Brown Soils. Variable crop yields but less frequent severe droughts.
3. Black Soils of the parkland. Better moisture conditions and better average yields than on the prairie. Severe droughts rarely experienced.
4. Thick Black and Greyish Black Soils of the parkland-forest belt. Good moisture conditions and high crop yields.
5. Grey Wooded Soils of the forest region. Moisture conditions good, but soils are low in organic matter and general fertility.
6. Grey Soils and Muskeg of the unsettled Northern Provincial Forest. - - - - - - Boundary of Northern Provincial Forest Reserves.

TABLE 1 - Response of barley to 110 kg/ha of 23-23-0 at various soil salinity levels, Siemens research-demonstration site, Rosthern, 1976.

Sample Location	Ave.* pH	Ave.* E.C.	Nutrient Levels kg/ha to 60 cm NO_3-N	15 cm P	15 cm K	Unfert. Yields kg/ha AGW**	Grain	% Yield Response # AGW	Grain
S-S-4	7.8	0.53	73.7	12.1	330.0	6593	3073	100.8	91.6
S-S-3	8.0	1.11	73.7	12.1	467.5	6135	2808	154.8	154.0
S-S-2	7.5	4.36	134.2	19.8	423.5	5476	2337	147.6	149.3
S-N-3	7.9	5.10	143.0	11.0	275.0	7596	2832	118.0	123.0
S-N-2	7.6	6.61	154.0	24.2	313.5	6750	2639	138.1	140.9
S-N-4***	8.1	7.22	124.3	17.6	341.0	833	338	207.3	228.7
S-N-1	7.8	8.95	137.5	36.3	335.5	3526	1558	116.8	118.6
S-S-1	8.0	12.79	275.0	25.3	302.5	1099	417	95.6	120.1

*Straight average of readings at depths of 0-15 cm, 15-30 and 30-60 cm.

**Above Ground Weight

***Yield could have been reduced due to flooding.

$\frac{\text{Fertilized Yield}}{\text{Unfertilized Yield}} \times 100$

SOIL SALINITY CROP TOLERANCE TESTING [2.]

H. M. (Chris) Holm

Introduction

An expanded design for testing crop tolerance to various salinity levels was instituted at two salinity research-demonstration sites in 1976 - the Lowe and Forman sites, both in the area S.E. of Moose Jaw. The crop tolerance plot on the Lowe site was severely damaged by flash flood in June and by drift soil accumulation in September. Consequently, the results from the Lowe plot are not considered reliable and will not be used in this report.

Purpose

The intent of this experiment is to determine salt tolerance of selected cereal, forage, oilseed and special crops at four basic levels of soil salinity:-

(1) Low Salinity Level (0-3 mmhos per cm conductivity)
   - little effect on crops although yields of sensitive crops may be reduced at upper readings.
(2) Medium Salinity Level (3-6 mmhos per cm conductivity)
   - yields of sensitive crops greatly reduced, yields of moderately sensitive crops reduced at upper readings.
(3) High Salinity Level (6-9 mmhos per cm conductivity)
   - yields of tolerant crops reduced.
(4) Very High Salinity Level (9-12 mmhos per cm conductivity)
   - only highly tolerant crops survive.

Knowledge within a plot area, of boundary limits for the four basic levels of salt concentration allows a comparison of crop response and ultimate yield within any one conductivity level and from one level to another.

Procedure

On May 20, 1976 four 60 metre rows of 20 plant types (7 cereal, 6 forage and 7 oilseed and special crops) were seeded at recommended field rates, using a rod row seeder across a salinity gradient. Rows were spaced 0.3 metres apart and plant types separated with 1.2 metre borders. (Refer Fig. 2, 3, Forman Site).

At emergence and during summer and at harvest each plant types performance was visually rated at each grid point on the salinity gradient.

At harvest, 1.8 metre lengths of the two centre rows of each plant type were sampled at each grid point on the salinity gradient for yield determination and statistical analysis. Soil samples from 0 - 15, 15 - 30, and 30 - 60 cm. depths were taken at each grid location at time of crop harvest.

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2. Credit is herein given to Larry Gutek, Howard Bjorge and John Buchan, Ag. Specialists with Plant Industry Branch, for assistance in field and laboratory work and statistical analysis for this phase of the program.

Results and Discussion

Tables 2 - 7 and Fig. 4 - 9 give yields of each crop in kg/ha at the various salinity levels. In this graphic representation of results, salinity readings for the 0 - 15 cm depth were used. Unfortunately, since detailed salinity readings were not available at seeding, some plant types are not represented in each salinity range.

Results, however, tend to indicate that Bonanza performs best of the barleys and Neepawa performs best of the wheats (Tables 2 and 3, Figs. 4 and 5). Comparing the cereals barley averaged far better than wheat and was much better than oats in 1976. (Table 4, Fig. 6).

Of the oilseed crops, flax appears better than mustard with rapeseed a poor third. (Table 5, Fig. 7). In special crops sunflowers outdistanced canary seed and sorghum by a wide margin. (Table 6, Fig. 8). Alfalfa, sweet clover and sugar beets established very well and gave unusually high yields. (Table 7, Fig. 9). These crops maintained their yields into the higher salinity levels which corroborates with other reported information. Since sufficiently high salinity levels were not present to really restrict growth of alfalfa, sweet clover and sugar beets in this experiment, these crops are not included in the regression analysis to follow. The grasses established poorly mainly because of surface crusting at seeding and were not harvested in 1976.

With statistical reporting of data in mind regression analysis was done on the original results. To illustrate this procedure, regression of the original yields (kg/ha) for representative crops Bonanza barley, Neepawa wheat, Dufferin flax and Krasnodarets sunflower, were plotted against electrical conductivity EC (mmhos/cm) and are shown in Fig. 10. In the regression analysis, salinity readings for the three sample depths were averaged and rounded off. It will be noted that when using the original data, the larger the negative regression coefficient the greater the crop tolerance to salinity. Because of inherent differences in crop yielding abilities, slope lines for the various crops cannot be directly compared from the original data.

In order to directly compare effects of salinity on crops with different yielding ability, the regression line was extended to zero and the yield at zero EC was interpreted to be an estimate of normal yield (i.e. no salinity influence). The plot data and normal yield for each crop type were then used to calculate percent of normal yield.

A second regression analysis was then done using percent of normal yield vs electrical conductivity to provide regression equations for the various crops. (Figs. 11 and 12). In percent of normal yield regression analysis, the smaller the negative slope the greater the crop tolerance to salinity, and the steeper the slope line the less the tolerance. Extent of salinity tolerance of the various crops thus become directly comparable.

The regression analysis based on percent of normal yield vs EC facilitates comparisons among the various varieties and crop kinds in respect to salinity tolerance. Summary table 8 lists the cereal, oilseed and special crops in order of salinity tolerance according to this method.

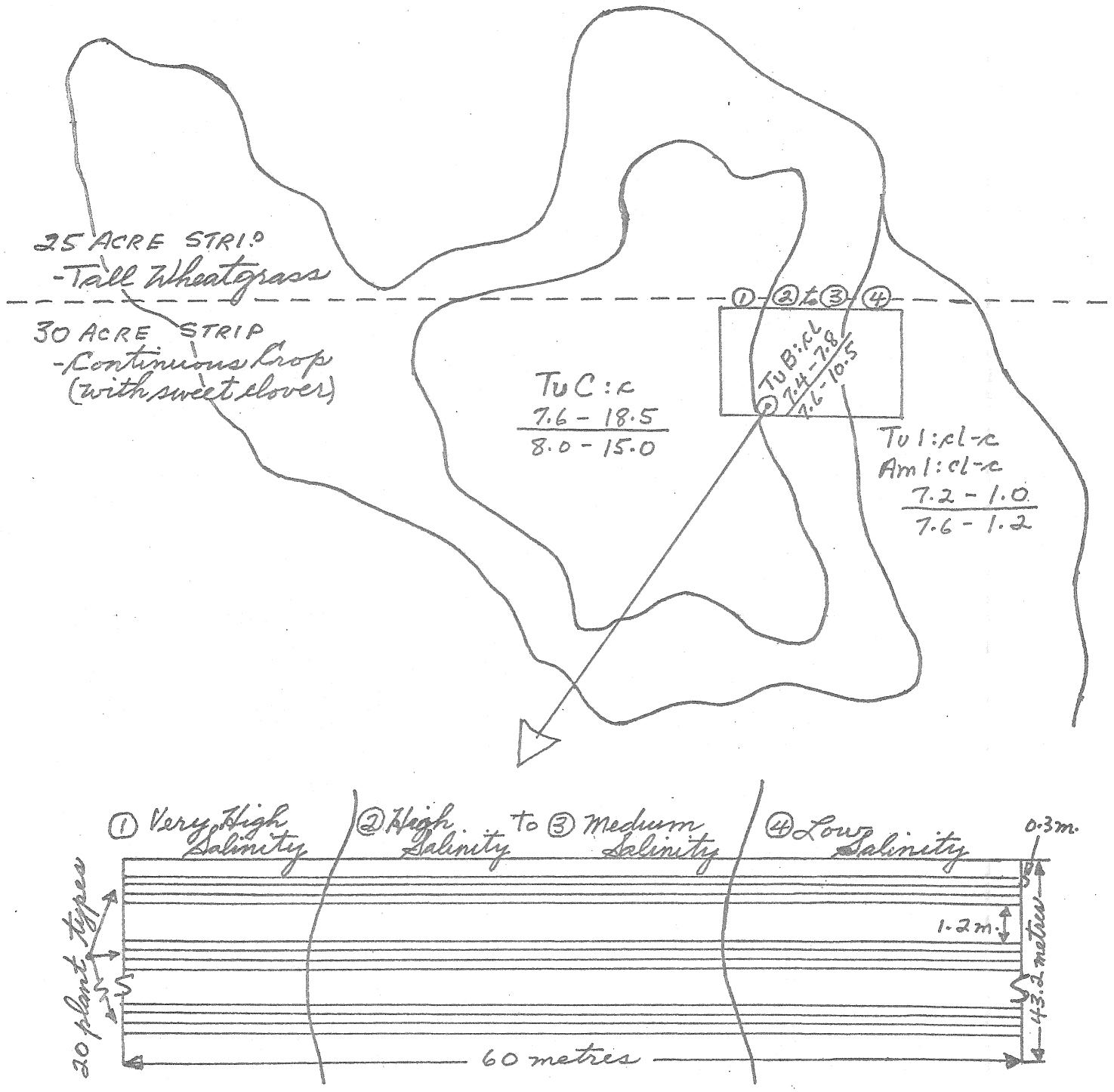

Fig. 2. Diagramatic sketch showing location and plot format of salinity crop tolerance test on Forman's research-demonstration site. Note soil classification indicating a salinity range from 18.5 mmhos/cm conductivity in surface of Tuxford C strongly saline soil, through 7.8 mmhos/cm in the surface of Tuxford B moderately saline soil to 1.0 mmhos/cm in the surface of essentially non-saline Tuxford 1 - Amulet 1 soil mixture.

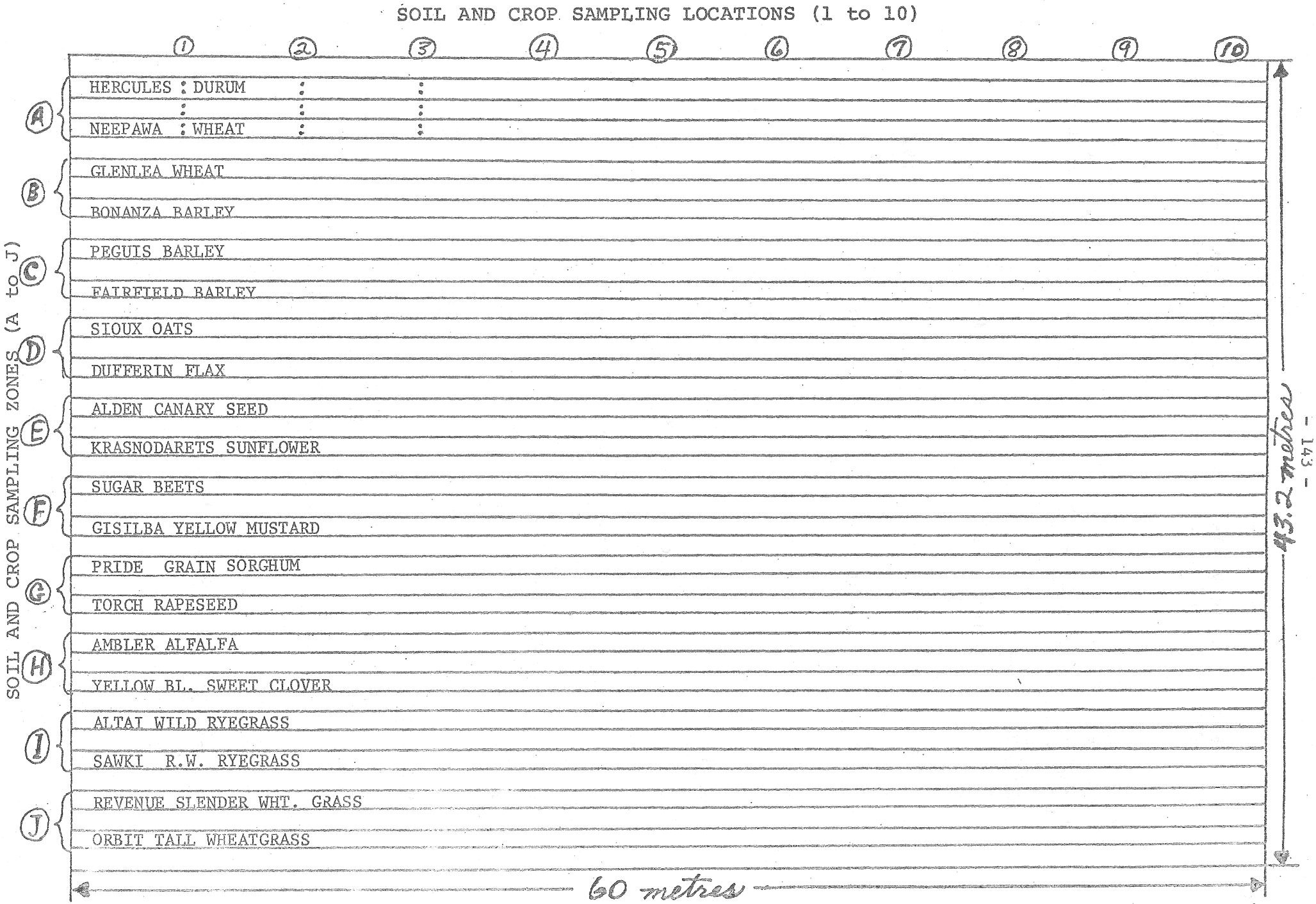

FIG. 3. Research design, Forman soil salinity crop tolerance plot, 1976.

TABLE 2. Barley variety yields at various soil salinity levels, Forman salinity crop tolerance test, 1976.

EC Range (mmhos/cm) 0-15 cm depth	Distribution	Yields (kg/ha)	Average Yield (kg/ha)
A. Bonanza			
0 - 3	4 locations	3063, 2931, 2670, 2534	2755
3 - 6	3 locations	2348, 1958, 1445	1917
6 - 9	3 locations	2766, 1018, 899	1561
9 - 12	nil locations	---	---
B. Peguis			
0 - 3	4 locations	3003, 2956, 2455, 1608	2506
3 - 6	6 locations	2951, 2861, 2364, 1918, 1384, 982	2077
6 - 9	nil locations	---	---
9 - 12	nil locations	---	---
C. Fairfield			
0 - 3	4 locations	2825, 2758, 2753, 1795	2533
3 - 6	6 locations	2552, 1916, 1827, 1560, 1086, 657.	1599
6 - 9	nil locations	---	---
9 - 12	nil locations	---	---

TABLE 3. Wheat variety yields at various soil salinity levels, Forman salinity crop tolerance test, 1976.

EC Range (mmhos/cm) 0-15 cm depth	Distribution	Yields (kg/ha)	Average Yield (kg/ha)
A. Neepawa			
0 - 3	5 locations	2486, 2124, 1648, 1648, 1414.	1864
3 - 6	1 location	771	771
6 - 9	3 locations	777, 523, 161.	487
9 - 12	1 location	509	509
B. Hercules Durum			
0 - 3	5 locations	1722, 1595, 1260, 1126, 1119.	1364
3 - 6	1 location	757	757
6 - 9	3 locations	402, 268, 7	226
9 - 12	1 location	34	34
C. Glenlea Utility			
0 - 3	4 locations	1956, 1695, 1615, 1441.	1677
3 - 6	3 locations	1347, 710, 637.	898
6 - 9	3 locations	945, 677, 248.	623
9 - 12	nil locations	---	---

TABLE 4. A. Average yield of three barley varieites. B. Average yield of three wheat varieties. C. Yield of one oat variety at various soil salinity levels, Forman salinity crop tolerance test, 1976.

EC Range (mmhos/cm) 0-15 cm depth	Distribution	Variety Yields (kg/ha)	Average Yield (kg/ha)
A. Barleys (Ave. of 3 varieties)			
0 - 3	12 locations	2755, 2506, 2533.	2598
3 - 6	15 locations	1917, 2077, 1599.	1864
6 - 9	3 locations	1561, --- ---	1561
9 - 12	nil locations	---	---
B. Wheats (Ave. of 3 varieties)			
0 - 3	14 locations	1864, 1364, 1677.	1635
3 - 6	5 locations	771, 757, 898.	809
6 - 9	9 locations	487, 226, 623.	445
9 - 12	2 locations	509, 34, ---	271
C. Oats (1 variety - Sioux)			
0 - 3	6 locations	1495, 1394, 1227, 1023, 761, 638.	1090
3 - 6	4 locations	1502, 1309, 445, 236.	873
6 - 9	nil locations	---	---
9 - 12	nil locations	---	---

TABLE 5. Oilseed Crop yields at various soil salinity levels, Forman salinity crop tolerance test, 1976.

EC Range (mmhos/cm) 0-15 cm depth	Distribution	Yields (kg/ha)	Average Yield (kg/ha)
A. Flax (1 variety - Dufferin)			
0 - 3	6 locations	1495, 1394, 1227, 1023, 761, 638.	1090
3 - 6	4 locations	1502, 1309, 445, 236.	873
6 - 9	nil locations	---	---
9 - 12	nil locations	---	---
B. Yellow Mustard (1 variety - Gisilba)			
0 - 3	1 location	786	786
3 - 6	5 locations	869, 654, 619, 603, 570.	663
6 - 9	3 locations	605, 193, 133.	310
9 - 12	1 location	170	170
C. Rapeseed (1 variety - Torch)			
0 - 3	nil locations	---	---
3 - 6	5 locations	693, 531, 472, 462, 168.	465
6 - 9	5 locations	156, 143, 69, 36, 24.	86
9 - 12	nil locations	---	---

TABLE 6. Special Crop yields at various soil salinity levels, Forman salinity crop tolerance test, 1976.

EC Range (mmhos/cm) 0-15 cm depth	Distribution	Yields (kg/ha)	Average Yield (kg/ha)
A. Sunflower (1 variety - Krasnodarets)			
0 - 3	2 locations	1797, 1114.	1455
3 - 6	4 locations	1474, 1384, 988, 503.	1087.
6 - 9	4 locations	1042, 773, 665, 539.	755
9 - 12	nil locations	---	---
B. Canary Seed (1 variety - Alden)			
0 - 3	2 locations	966, 888.	927
3 - 6	4 locations	888, 246, 200, 169.	376
6 - 9	4 locations	537, 455, 190, 18.	300
9 - 12	nil locations	---	---
C. Sorghum (1 variety - Pride grain)			
0 - 3	nil locations	---	---
3 - 6	5 locations	854, 656, 530, 377, 45.	492
6 - 9	5 locations	189, 63, 9, zero, zero.	52
9 - 12	nil locations	---	---

TABLE 7. Forage Crops and Sugar Beet yields at various soil salinity levels, Forman salinity crop tolerance test, 1976.

EC Range (mmhos/cm) 0-15 cm depth	Distribution	Yields (kg/ha)	Average Yield (kg/ha)
A. Alfalfa (Rambler)			
0 - 3	nil locations	---	---
3 - 6	3 locations	7155, 4770, 4371.	5432
6 - 9	3 locations	5963, 5963, 1592	4506
9 - 12	4 locations	5664, 1592, 1193, 796.	2286
B. Sweet Clover (Yellow Blossom)			
0 - 3	nil locations	---	---
3 - 6	3 locations	9760, 7590, 5059.	7469
6 - 9	3 locations	6508, 5784, 1085.	4459
9 - 12	4 locations	7590, 4338, 2531, 2170.	4157
C. Sugar Beets			
0 - 3	1 location	6712	6712
3 - 6	5 locations	5481, 4969, 4196, 3136, 2282.	4013
6 - 9	3 locations	6245, 3271, 2812.	4109
9 - 12	1 location	3747	3747

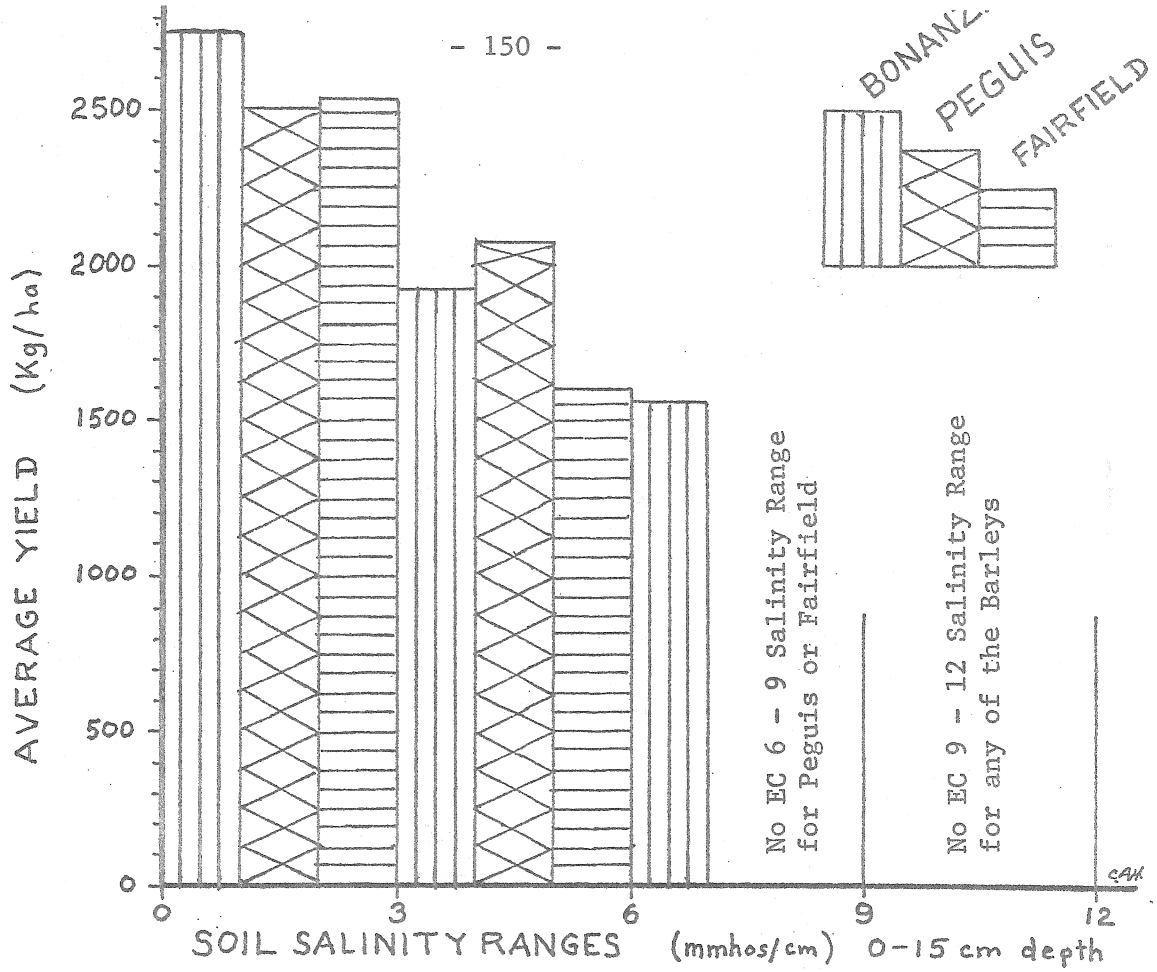

FIG. 4. Average barley variety yields at various soil salinity levels, Forman salinity crop tolerance test, 1976

FIG. 5. Average wheat variety yields at various soil salinity levels, Forman salinity crop tolerance test, 1976.

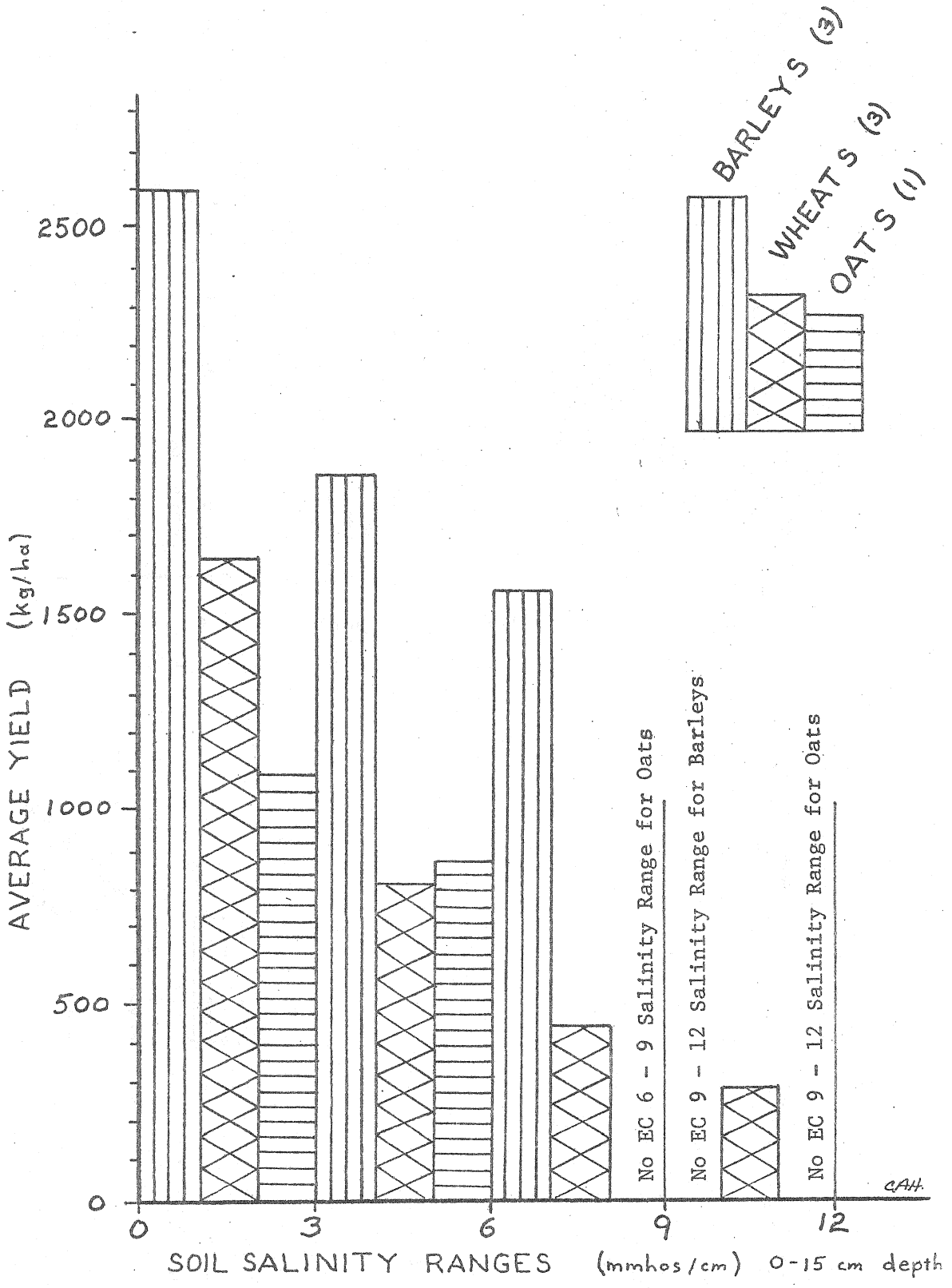

FIG. 6. Average barley yields (3 varieties) vs average wheat yields (3 varieties) vs average oats yield (1 variety) at various soil salinity levels, Forman salinity crop tolerance test, 1976.

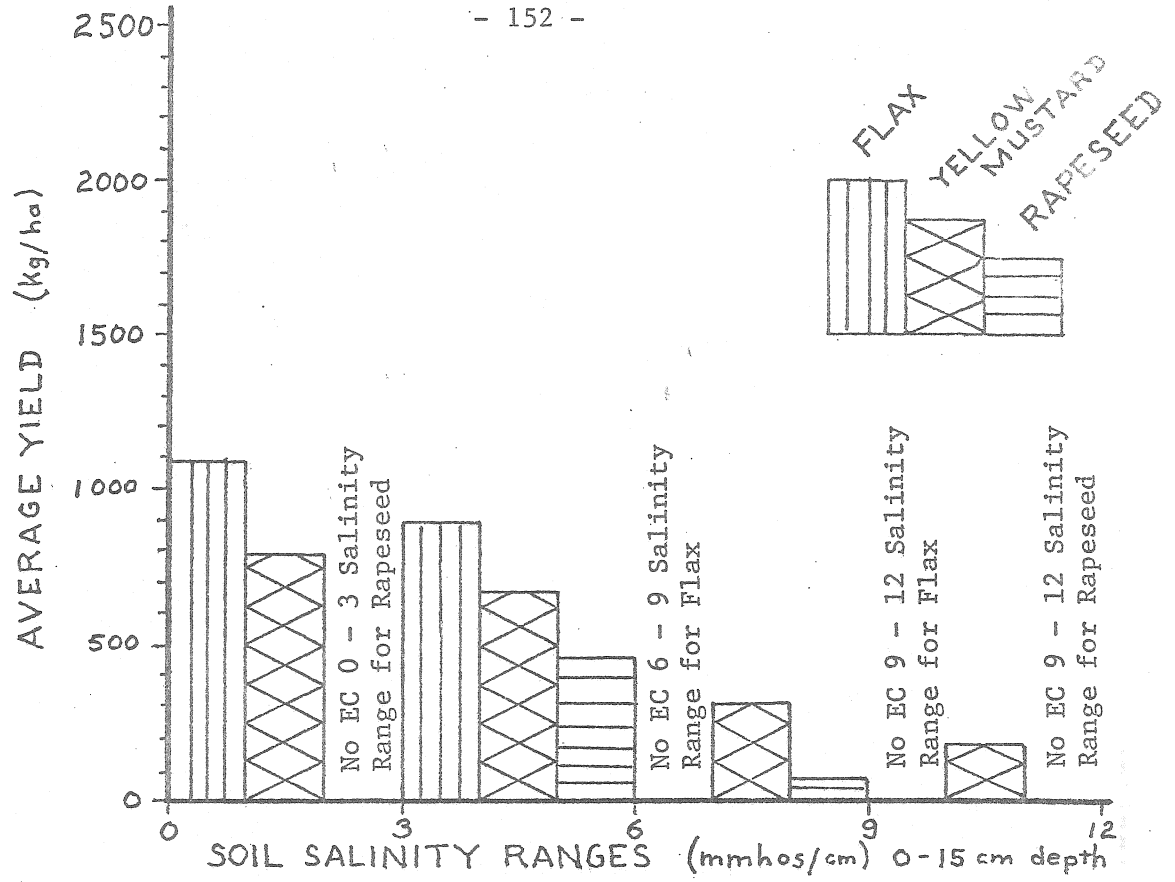

FIG. 7. Average oilseed crop yields at various soil salinity levels, Forman salinity crop tolerance test, 1976.

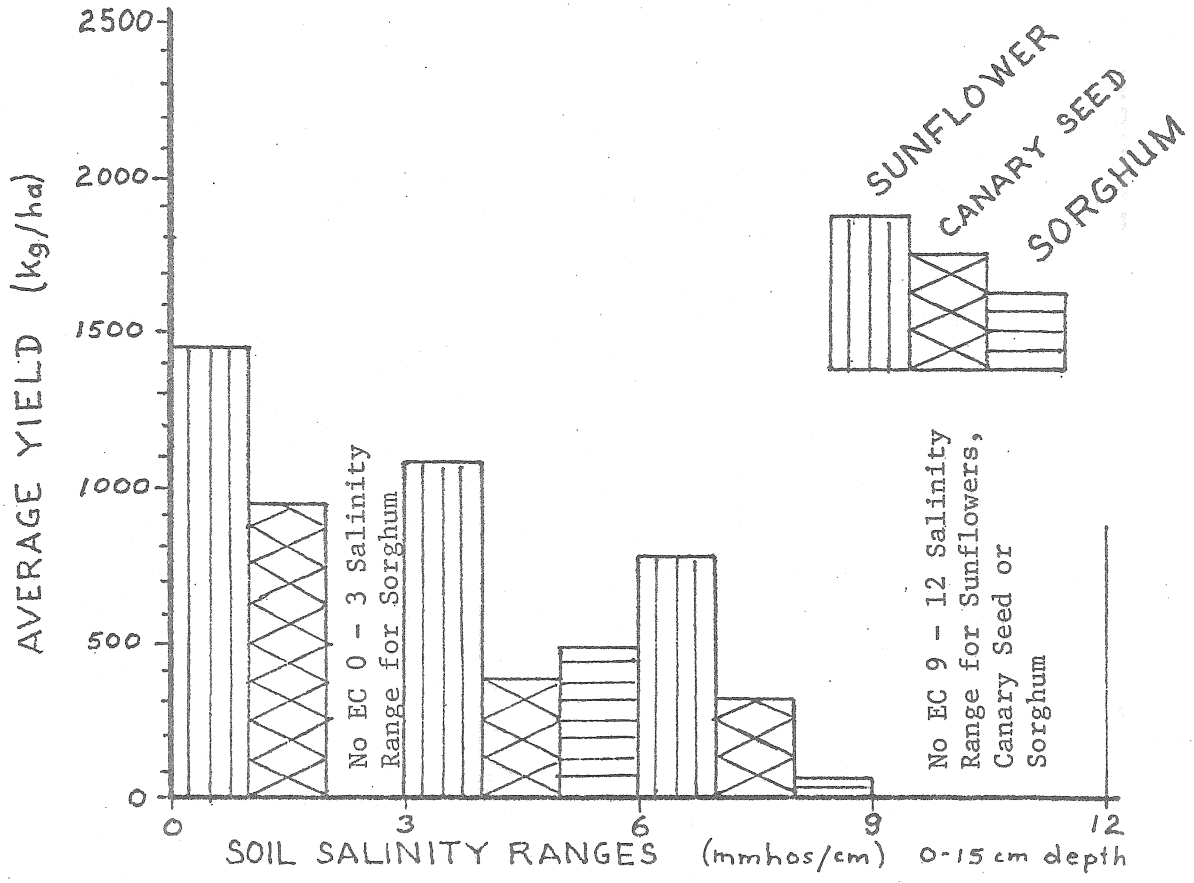

FIG. 8. Average special crop yields at various soil salinity levels, Forman salinity crop tolerance test, 1976.

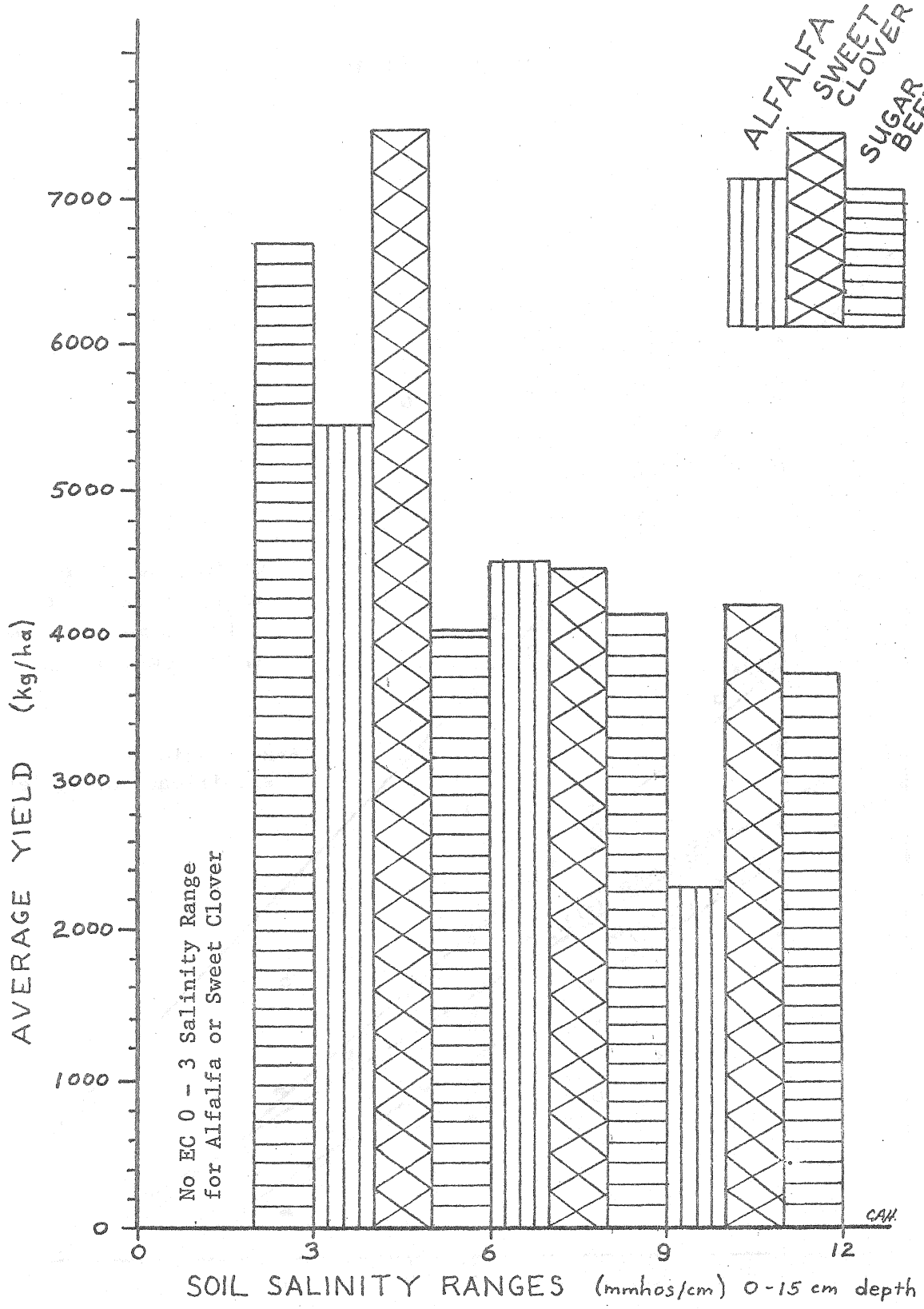

FIG. 9. Forage crops and sugar beet yields at various soil salinity levels, Forman salinity crop tolerance test, 1976.

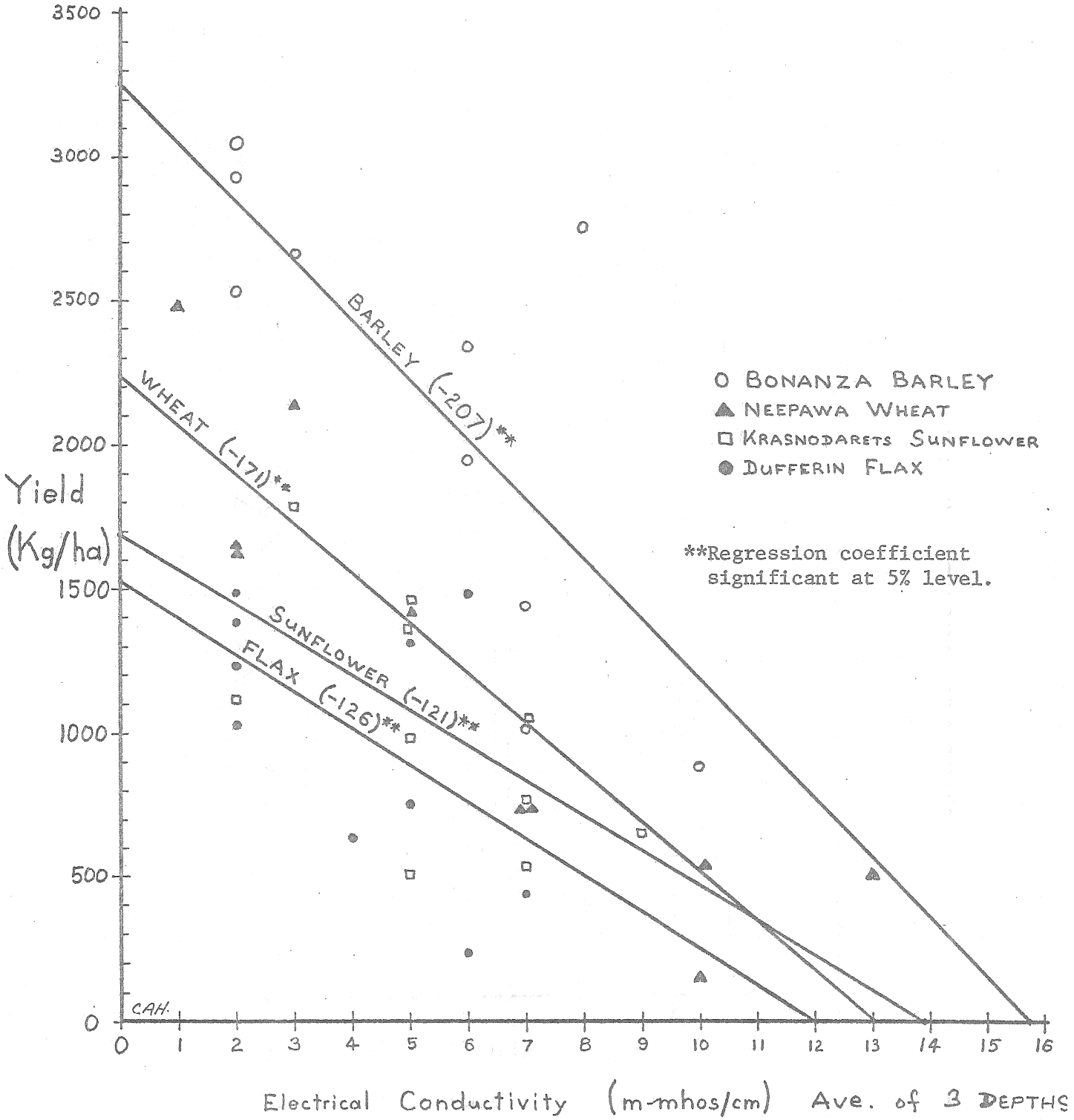

FIG. 10. Regression of crop yield vs salinity for representative crops from original data, Forman research-demonstration site, 1976. Because of inherent differences in crop yielding abilities, slope lines for the various crops cannot be directly compared from the original data.

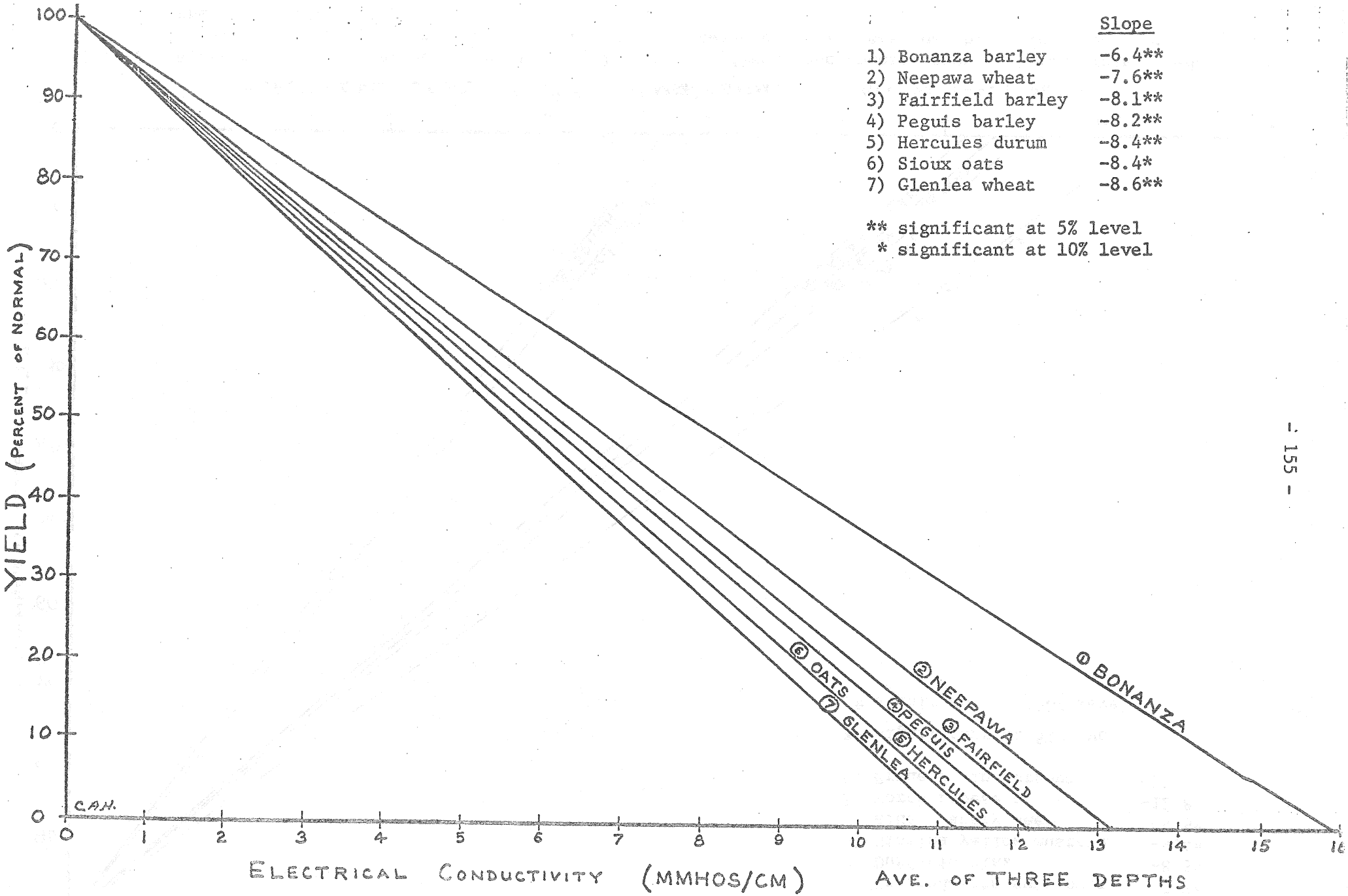

FIG. 11. Regression of percent normal yield vs salinity for cereal crops, Forman research-demonstration site. Direct comparison of salinity tolerance between crops is here possible. The steeper the slope line the less tolerant the crop.

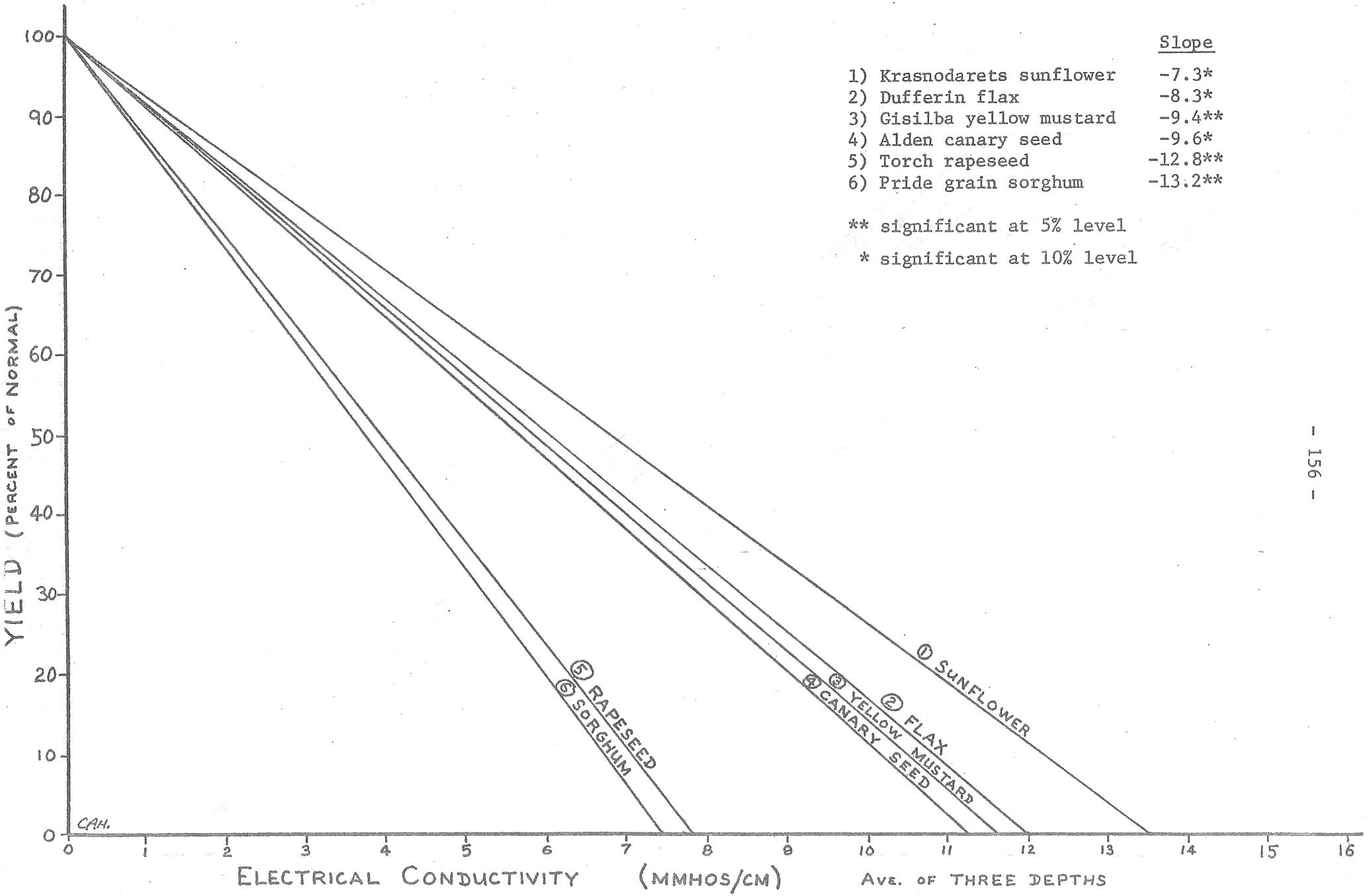

FIG. 12. Regression of percent normal yield vs salinity for oilseed and special crops. Forman research-demonstration site. Direct comparison of salinity tolerance between crops is here possible. The steeper the slope line the less tolerant the crop.

TABLE 8. Summary of Regression Equations for Percent of Normal Yield vs Salinity.

CROP	REGRESSION EQUATION	t-VALUE
Bonanza Barley	y = -6.4 x +100	3.20**
Krasnodarets Sunflower	y = -7.3 x +100	2.02*
Neepawa Wheat	y = -7.6 x +100	5.89**
Fairfield Barley	y = -8.1 x +100	2.60**
Peguis Barley	y = -8.2 x +100	3.64**
Dufferin Flax	y = -8.3 x +100	1.86*
Hercules Durum	y = -8.4 x +100	5.95**
Sioux Oats	y = -8.4 x +100	1.91*
Glenlea Wheat	y = -8.6 x +100	7.25**
Gisilba Yellow Mustard	y = -9.4 x +100	3.13**
Alden Canary Seed	y = -9.6 x +100	1.86*
Torch Rapeseed	y = -12.8 x +100	4.00**
Pride Grain Sorghum	y = -13.2 x +100	3.00**

** denotes significant regression coefficient at 5% level of significance. (t at 0.05, 8DF = 2.306)

* denotes significant regression coefficient at 10% level of significance (t at 0.10, 8DF = 1.860)

Note - increasing slope (-6.4 to -13.2) indicates a decreasing crop tolerance to soil salinity.